Health Consultation

Exposure Investigation Report

Public Comment Release

A Pilot Exposure Investigation:
Dioxin Exposure in Adults
Living in the Tittabawassee River Flood Plain
Saginaw County, Michigan

EPA FACILITY ID: MID980994354

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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Prepared by:

Michigan Department of Community Health
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Acronyms and Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CI	confidence interval
CDC	Centers for Disease Control and Prevention
DLC	dioxin-like compound
EMEG	environmental media evaluation guide
MDCH	Michigan Department of Community Health
MDEQ	Michigan Department of Environmental Quality
PCB	polychlorinated biphenyl
PEI	Pilot Exposure Investigation
pg/g	picograms per gram
ppt	parts per trillion
TCDD	tetrachlorodibenzo-*p*-dioxin
TEF	toxic equivalency factor
TEQ	toxic equivalent
EPA	U.S. Environmental Protection Agency

Summary

The Michigan Department of Community Health (MDCH), in cooperation with the Michigan Department of Environmental Quality (MDEQ) and the Agency for Toxic Substances and Disease Registry (ATSDR), conducted a Pilot Exposure Investigation (PEI) in the flood plain of the Tittabawassee River. The purpose of the PEI was to test exposure investigation methods and to provide information about the levels of dioxin-like compounds (DLCs) in soil, indoor dust, and human blood samples. Properties that were frequently flooded were identified and, with the consent of the property owners, soil was tested to verify DLC soil contamination. Residents on properties where the DLC level in surficial soils was elevated above the MDEQ residential soil criterion of 90 parts per trillion (ppt) were asked to allow MDCH to take dust samples in their homes, to provide a blood sample, and to respond to a questionnaire designed to identify occupational and dietary exposure to DLCs.

The interview questionnaire and the soil, dust, and blood sampling methods were adequate to meet the purpose of the PEI. However, the occupational history section of the interview questionnaire was confusing to participants and should be revised before the questionnaire is used again.

Indoor dust samples collected from homes confirmed the presence of DLCs in the indoor environment. Results obtained from the questionnaire indicated that participants had not been exposed to DLCs at their jobs. Some participants indicated they had eaten fish or wild game from the Tittabawassee River or flood plain, but not recently or in great quantity.

The level of DLCs measured in participants' blood serum samples fell within the range of preliminary estimated background levels for people with no known exposure to dioxins and furans beyond background. However the mean (average) blood levels for the participants were higher than the mean background estimates for people the same age. In addition, total dioxin toxic equivalent (TEQ) concentrations in five PEI participants were elevated above the 90^{th} percentile of the age-specific estimated background levels. TEQ concentrations in the blood of two of these five were also elevated above the 95^{th} percentile of the estimated background levels.

The participants were selected for the PEI because the soil on their property was known to be impacted by the dioxin contamination. Because the selection process was biased and because of the small number of people participating in this investigation, generalizing from these limited results to the larger population of people living in or near the flood plain it is not possible.

Purpose

In March 2002, the Michigan Department of Community Health (MDCH), in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR), released a "Petitioned Health Consultation: Tittabawassee River Floodplain Dioxin Contamination South of Midland, Midland and Saginaw Counties, Michigan" for public comment. The final version of the Public Health Consultation was released in August 2004, including the comments received during the comment period and the agencies' responses. The Public Health Consultation addressed concerns related

to dioxin contamination in soil samples taken from the floodplain of the Tittabawassee River downstream of Midland (MDCH 2004b).

Dioxins are a group of chlorinated chemicals with similar structures and chemical properties. This group of chemicals, which includes chlorinated dioxins, furans, and some coplanar polychlorinated biphenyls (PCBs), is often referred to collectively as "dioxins" or "dioxin-like compounds" (DLCs). Because the data to determine if people living in the flood plain are being exposed to DLCs in the soil were not available, the Public Health Consultation recommended that ATSDR and MDCH design an evaluation of site-specific exposure factors for residents of the properties in the flood plain, including biota sample analysis if feasible (MDCH 2004b).

On December 1, 2003, MDCH released for public comment a draft protocol for a Pilot Exposure Investigation (PEI) of dioxin exposure in adults living in the Tittabawassee River flood plain. The MDCH released a final PEI protocol on May 25, 2004 that included responses to comments received during the comment period. The full PEI protocol is available at http://www.michigan.gov/mdch-toxics. The purposes of the PEI were:

- To provide information on the levels of dioxins in soil, indoor dust, and blood samples for a limited number of residents of the flood plain.

- To test sampling criteria, questionnaire, and blood and indoor dust sampling methods prior to the implementation of a larger investigation.

The current report provides the results of soil, indoor dust, and human blood serum analyses for 20 residents living on frequently flooded property within the Tittabawassee River flood plain.

Background

The Dow Chemical Company (Dow), founded in 1897, operates a chemical manufacturing plant in the city of Midland, Michigan. The Dow plant encompasses approximately 1,900 acres on the southern perimeter of the city. The Tittabawassee River flows through the plant site and then southeast to the confluence with the Cass and Shiawassee rivers to form the Saginaw River, which continues northeast to the Saginaw Bay of Lake Huron (Figure 1).

Chlorophenol production began at the Dow Midland site in about 1915. Wastes generated from this process were initially disposed of in 600 acres of on-site waste ponds. During high flow periods in the early 1900s, wastes from these ponds would be intentionally released to the Tittabawassee River (Brandt 1997). Dow currently operates its own on-site wastewater treatment plant. However, historical releases of DLCs have resulted in contamination of Tittabawassee River sediments and biota. The Tittabawassee River often overflows its banks as a result of heavy rains in the spring and the fall, and melting snow in the spring. The floodwaters have deposited DLC contaminated sediments onto upland areas resulting in soil contamination extending in some locations to several feet below the ground surface. The depth of the contamination indicates that DLCs have been accumulating in the Tittabawassee River flood plain over an extended period of time (MDEQ 2003).

The Michigan Department of Environmental Quality (MDEQ) sampled soil and sediment in the Tittabawassee River and flood plain. In its Phase II final report released in June of 2003, the MDEQ concluded that DLC contamination is extensive in soils and sediments throughout the 100-year flood plain downstream of Midland. The degree of contamination on a property appears to be dependent upon depositional characteristics of the river and how frequently a property is flooded (MDEQ 2003).

Methods

DLCs are most often found as a group in environmental samples and in biota, including human blood serum and other tissues. Each chemical member of the group is called a congener. The most toxic congener in the group of DLCs is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD). Toxic equivalency factors (TEFs) have been developed to compare the relative toxicity of other DLCs to that of 2,3,7,8-TCDD. The levels of DLCs measured in a sample are multiplied by a TEF to produce a 2,3,7,8-TCDD toxic equivalent or TEQ concentration. The resulting TEQs for all DLCs measured in a sample are then added together to determine the total dioxin TEQ concentration for that sample (De Rosa 1997a,b). Total dioxin TEQs in all media sampled in this investigation were calculated using the 1998 World Health Organization TEFs (Van den Berg et al. 1998).

Target Population

In the summer and fall of 2003, the MDEQ sampled soil on 22 properties believed to be frequently flooded by the Tittabawassee River. Analysis of surficial soils for chlorinated dioxins and furans indicated DLC contamination above the MDEQ criterion of 90 parts per trillion (ppt or ng/kg) on 15 properties (MDEQ 2004).

The residents of these 15 properties were contacted to determine their willingness and ability to participate in the blood and dust collection activities of the PEI. Participation was limited to adults aged 18 years or older who had lived at their current residence in the flood plain for at least 5 years. Individuals were excluded if they were pregnant, had breastfed a child in the last 6 months, weighed less than 95 pounds, had lost more than 15 pounds in the last year, or if they had a blood clotting disorder or other medical condition that precluded them from donating an 80 milliliter (ml) blood sample. The residents of four properties were excluded either because of recent weight loss or because they declined continued participation in the PEI, leaving 11 eligible properties.

The PEI protocol detailed a participant scoring system in the event that MDCH identified more than 25 potential participants. This system proved to be unnecessary because only 21 potential participants were identified.

Soil Sampling and Analysis

Residents were asked to identify which entrance to the home was most frequently used and other areas of frequent use on their properties. The MDEQ collected surface soil samples near the house entrance used most often and another sample was collected in a high-use area (e.g., play area where adults may congregate with children, garden area). Additional soil samples were

taken as necessary to characterize exposures and contamination, including the frequently flooded area(s) of the property.

Samples were manually collected using hand augers. Two to five surficial soil samples were taken on each participant's property. The depth of the samples ranged from one to three inches below the ground surface. Decisions regarding the exact location of a sample were made on the basis of the physical characteristics of the sample site. Vegetative cover was removed before sample collection. The hand auger was decontaminated before sampling the next location, and used sample pans, spoons, and gloves were discarded.

Samples were handled, stored, and shipped in accordance with applicable U.S. Environmental Protection Agency (EPA) and Department of Transportation guidelines. Discrete soil samples were analyzed at Triangle Laboratory, Durham, North Carolina for DLCs using EPA Method 1613.

Indoor Dust Sampling and Analysis

Two indoor floor dust samples were collected inside of each home following the EPA Standard Operating Procedure detailed in the PEI protocol. One sample was taken inside the most frequently used door to the home and another was taken from an area of frequent use (e.g., the family room or living room).

A Nilfisk® vacuum equipped with a HEPA filter was used to vacuum an area sufficient to yield a minimum of 10 grams of dust. A square-meter was measured and marked using masking tape and additional area was added as necessary. Surfaces vacuumed included wood, tile, and carpet or rugs. Surface type and the total area of sample collection were recorded. Dust samples were analyzed for DLCs at Eno River Labs (formerly Triangle Laboratory), Durham, North Carolina using EPA Method 1613.

Blood Sampling and Analyses

Participants were given an appointment to come to the Greenpoint Nature Center in Saginaw, Michigan where the blood samples were collected by an MDCH phlebotomist. One participant did not arrive for the scheduled appointment and was dropped from the PEI. Thus, 20 blood samples were collected.

Blood samples were collected in eight 10-ml glass Vacutainer® tubes. After collection, blood samples were held at room temperature for 1-2 hours and allowed to clot. The samples were stored on ice and delivered to the Centers for Disease Control and Prevention (CDC), National Center for Environmental Health (NCEH) Laboratory in Atlanta, Georgia, for analyses.

The serum samples were analyzed for chlorinated dioxins and furans and coplanar PCBs by the NCEH laboratory using gas chromatography/isotope dilution-high resolution mass spectroscopy. These measurements were not analyzed for the level of mono-ortho-substituted PCBs, which may add substantially to the sum TEQ. The blood serum samples were also analyzed for total lipid content, so the results could be expressed as a blood lipid concentration. All DLC serum levels described in this report are given in picograms per gram of blood lipid (pg/g or ppt).

PEI blood serum results were compared to preliminary background estimates for age-group specific dioxin TEQ levels developed by CDC and ATSDR scientists. The background estimates shown in Table 1 were drawn between 1996 to 2001 from 588 participants with no known exposure to dioxin-like compounds other than background. Known exposure is defined as documented epidemiological evidence of previous occupational, diet, or residential proximity to potential industrial exposure sources (Patterson et al., 2004).

Table 1 provides the estimated average or "mean" TEQ background level by age group. The background data are grouped by age because TEQ levels increase with age. Table 1 also presents the lowest (minimum) and highest (maximum) TEQ level as well as the 75th, 90th, and 95th percentile TEQ level for each age group. A percentile is a value on a scale of 1 to 100 that indicates the percent of the data that are equal to or below that value. For example, in the table below, the mean dioxin TEQ for the 90th percentile is 29.5 for people 45 to 59 years old. This means that 90 of 100 people will likely have a dioxin TEQ of 29.5 or less.

Table 1. Preliminary Estimates for Background Total Dioxin TEQ Levels (pg/g of lipid), by Age Group.

Age Group In years	Mean	75th Percentile	90th Percentile	95th Percentile	Minimum TEQ Observed	Maximum TEQ Observed
15-29	6.4	7.8	11.7	14.0	0.0	53.9
30-44	11.8	16.6	21.1	23.2	0.2	50.4
45-59	16.9	22.3	29.5	32.8	0.8	55.4
60+	36.1	45.6	69.2	85.4	3.4	146.4

(Patterson et al 2004)

Interviews
An interview questionnaire was administered to each study participant at the same time blood was collected. The questionnaire was designed to identify personal behaviors (e.g., consumption of sport caught fish, occupation) or characteristics (e.g., gender, age, diet, weight) that could affect exposure and dioxin body burdens.

Consent Form
Prior to administration of the PEI questionnaire or biological and environmental testing, each participant in the PEI signed an informed consent form.

Results

Soil Results
Table 2 presents total dioxin TEQ concentrations (ppt) in surficial soils on the 15 properties chosen for the PEI. The number of samples taken on each property ranged from two to five. Sample results ranged from <5 ppt to 2,530 ppt.

Table 2 presents the sampling results progressing from right to left from the house on the property toward the Tittabawassee River. In general, DLC concentrations tended to be higher in soil samples taken nearest the Tittabawassee River compared to those taken nearest the most frequently used entrance to the home. However, this trend was not apparent at all properties.

One possible explanation is that flood plain soil had been moved and used as fill material when these homes were built.

Table 2. Total Dioxin TEQ Levels (ppt) in Soil Samples from the Pilot Exposure Investigation

House	⟶	Tittabawassee River
50	270	410
240	50, 30	810
80	No intermediate samples.	240
<5	80, 150	400
30	<5, 370, 280	920
1110	<5	400
80	180	550
70	20, 50	260
50	90, 850	1100
50	50, 60	250
10	90, 230	230
260	310	270
30	410, 2530	1130
770	45, 81, 240	450
990	300	580

(MDEQ, unpublished data, 2004)

Indoor Dust Results

Two indoor dust samples were taken from each of the 20 participant's homes for a total of 11 residences sampled. An adequate quantity of dust was obtained for all samples. Indoor dust results ranged from 5 to 268 ppt total dioxin TEQs. Indoor dust sample results are provided in Table 3. The order in which properties are presented does not correspond to that shown in Table 2 to prevent matching of indoor dust results to previously presented soil data.

Table 3. Total Dioxin TEQ Levels (ppt) in Indoor Dust Samples from the Pilot Exposure Investigation

Frequently Used Entrance	Living Area
12.8	27.8
115	56.9
60.4	71.7
57.7	268
33.8	38
5	20.2
26	60.1
36.6	54.5
153	152
111	67.2
83	148

(MDCH, unpublished data, 2004)

Blood Results

Blood serum samples from 20 adults were analyzed for DLCs. Nineteen of the samples are described in this report. One sample is not included in the report to protect the identity of the participant. Table 2 compares the PEI blood total dioxin TEQ results to the CDC/ATSDR background estimates. Data are provided only for the two age groups with enough participants to protect the identity of the individuals.

Table 4: Comparison of Total Dioxin TEQ levels (pg/g of lipid) from the Pilot Exposure Investigation to Preliminary Background Estimates by Age Group.

Study	Age Group	Number of People	Mean	95% confidence interval	Range
PEI	45 – 59	10	26.8	22.0, 30.9	16.7 – 37.4
Background	45 – 59	160	16.9	15.4, 18.4	0.8 – 55.4
PEI	60 +	9	40.2	27.8, 52.7	17.7 – 74.7
Background	60 +	113	36.1	31.5, 40.7	0.4 – 146.4

Patterson et al 2004

Table 2 provides the mean (average) level calculated for each age group in both the PEI and in the background data. Because these mean levels are only estimates, 95 percent (95%) confidence intervals are also provided. Confidence intervals account for the variability in the data used to calculate the mean. The true sample mean is expected to fall between the lower and upper limits of the confidence interval 95% of the time.

Ten PEI participants were between 45 and 59 years old. The mean total dioxin TEQ for this age group is 26.8 ppt. This level is higher than the mean total dioxin TEQ of 16.9 for comparison TEQs for this age group. In addition, the 95% confidence interval of 22.0 to 30.9 ppt for the PEI mean does not overlap the confidence interval of 15.4 to 18.4 ppt for the background mean. On the average, dioxin TEQ levels found in the PEI participants ages 45 to 59 years are higher than TEQ levels included in the background estimates for this age group.

As indicated in the final PEI protocol (MDCH 2004a), blood serum dioxin results greater than the 90^{th} percentile of the preliminary age-adjusted estimate background data for are considered to be elevated. The 90^{th} percentile estimated background total dioxin TEQ is 29.5 ppt for people ages 45 to 59 years (Table 1). Four of the total dioxin TEQ levels for participants in this age group were greater than the 90^{th} percentile. In addition, two of these four participants had total dioxin TEQ serum levels greater than the 95^{th} percentile of 32.8 ppt.

Figure 2 presents a comparison of the estimated background total dioxin TEQ levels and the PEI results for people aged 45-59 years. The total dioxin TEQ levels are broken down into 5 ppt ranges and are shown on the horizontal axis. The vertical axis presents the percentage of blood samples in the PEI (darker bars) compared to the background estimates (lighter bars) for each range of total dioxin TEQ levels.

Nine PEI participants were 60 years of age or older. The mean total dioxin TEQ for this age group is 40.2 ppt. This level is higher than the mean of 36.1 for the estimated background TEQs for this age group. However, the 95% confidence interval of 27.8 to 52.7 ppt for the PEI mean overlaps the confidence interval of 31.5 to 40.7 ppt for the background mean. Therefore, it is not certain if this difference in average TEQ levels reflects a real difference between the PEI participants and the background estimates for this age group. Figure 3 presents the total dioxin TEQ results for people aged 60 years for the PEI and the estimated background data.

The 90th percentile estimated background total dioxin TEQ is 69.2 ppt (Table 1). Only one of the total dioxin TEQ levels for participants in this age group were greater than the 90th percentile. None of the participants in this age group had total dioxin TEQ serum levels greater than the 95th percentile of 85.4 ppt.

Table 3 presents a comparison of the PEI and estimated background data for 2,3,7,8-TCDD TEQ only. The mean for each of the PEI age groups is higher than the mean of the estimated background TEQ levels.

Table 5: Comparison of 2,3,7,8-TCDD TEQ Levels (pg/g of lipid) from the Pilot Exposure Investigation to Preliminary Background Estimates by Age Group.

Study	Age Group	N	Mean	95% confidence interval	Range
PEI	45 – 59	10	3.5	2.6, 4.5	1.7 – 6.3
Background	45 – 59	160	1.9	1.2, 1.6	0.3 – 9.3
PEI	60 +	9	5.9	2.6, 9.2	0.7 – 15.5
Background	60 +	113	3.9	3.2, 4.6	0.3 – 22.6

Patterson et al 2004

The mean of 3.5 ppt for 2,3,7,8-TCDD TEQ levels in the PEI participants ages 45 to 59 years is higher than the mean of 1.9 ppt for the estimated background 2,3,7,8-TCDD TEQ levels for this age group. In addition, the 95% confidence intervals for the means do not overlap. On the average, 2,3,7,8-TCDD levels found in the PEI participants ages 45 to 59 years are higher than levels included in the background estimates for this age group.

The mean of 5.9 ppt for 2,3,7,8-TCDD TEQ levels in the PEI participants ages 60 years and older is higher than the mean of 3.9 ppt for the estimated background 2,3,7,8-TCDD TEQ levels for this age group. In this age group the 95% confidence intervals for the means overlap. Therefore, whether the difference in average levels reflects a real difference between the PEI participants and the background estimates is not certain .

Background data for other dioxin and furan congeners are not currently available but may be addressed in future documents related to the Tittabawassee River.

Interview Results

Adequacy of Design

Overall, the interview questionnaire was of adequate design to elicit information about personal characteristics or behaviors that could affect exposure to DLCs. However, redundancy in the "Occupational History" series of questions (29 to 42) resulted in some confusion on the part of both the interviewers and the participants.

Participant Characteristics

Participants ranged in age from 18 to 79 years. Residence time at their property within the Tittabawassee River flood plain ranged from 11 to 39 years. About half of the participants were male (n=11) and half were female (n=9).

Seven of the nine female participants had given birth to one to four children, and four of these women had breastfed their children. The most recent birth occurred in 1986.

Eleven participants reported having ever smoked cigarettes; two of these reported currently smoking. Thirteen reported using pesticides around their home, primarily for insect control. Four participants reported getting their drinking water from a private well, but none of the wellheads had ever been submerged during flooding of the Tittabawassee River.

Occupational History

One participant reported work experience with hazardous waste. However, further inquiry indicated this person had used organic solvents rather than materials that might be expected to contain DLCs. No participant indicated that they had ever been employed in jobs where they manufactured or used 2,4-D, 2,4,5-T, hexachlorophene, or pentachlorophenol. None of the participants indicated they had worked in brush or hardwood control, railroad right-of-way clearance, chemical warehouses, paper mill pond management, waste incineration, or had handled phenolic wastes. Participants reported a variety of previous work experience that included sales, general office work, homemaker, electrician, machine operator, and the practice of medicine.

Sport-Caught Fish Consumption

Sixteen participants indicated they had ever eaten sport-caught fish from Michigan lakes and streams, and 10 of these indicated they had done so in the last 5 years. Eight participants indicated they had eaten fish from the Saginaw River or Saginaw Bay in the last 5 years. Six participants indicated they had ever eaten fish from the Tittabawassee River, however only two had eaten these fish in the last 5 years. Only walleye were reportedly eaten in the year before the investigation. Walleye and bass were most often eaten in prior years; however, one participant reported having at one time eaten all species of sport fish from the Tittabawassee River including carp and catfish.

Wild Game Consumption

Nine participants reported having ever eaten locally harvested wild game and five of these had eaten game harvested from the Tittabawassee River flood plain. The most frequently eaten

species were squirrel, rabbit, and deer. The reported number of meals per year of these game species was no more than four to six.

Home-Raised Meat and Produce

Six participants reported having ever eaten home-raised meat and two of these reported having eaten meat raised in the flood plain of the Tittabawassee River. Within the year before the PEI, one person had eaten home-raised lamb from the flood plain. Another participant reported having eaten home-raised beef in prior years.

Sixteen participants reported having eaten produce grown in the flood plain of the Tittabawassee River. Two participants reported having eaten eggs from chickens that were kept on property in the flood plain and two others reported not knowing whether they had eaten eggs that were produced in the flood plain.

Discussion

Soil

DLC concentrations in one or more surficial soil samples at all properties included in the PEI exceeded the MDEQ residential clean up criterion of 90 ppt and the ATSDR screening level of 50 ppt.

The MDEQ clean up criterion for DLCs is protective of dermal contact with and incidental ingestion of soil under a residential exposure scenario. MDEQ uses an age adjusted formula that assumes exposure both as a child and as an adult, and a mix of average and upper bound exposure assumptions to calculate a soil DLC concentration that is protective of a reasonable maximum exposure. The current MDEQ criterion for DLCs is calculated from a cancer potency value based on liver cancer incidence in rats. The MDEQ assumes that 3 percent of DLCs in soil will be absorbed through the skin and 50 percent will be absorbed through the gastrointestinal tract if soil is ingested.

The ATSDR screening level of 50 ppt for DLCs is the chronic environmental media evaluation guide (EMEG) for 2,3,7,8-TCDD in soil. The EMEG was developed from the ATSDR minimum risk level (MRL) on the basis of neurodevelopmental effects observed in offspring of female rhesus monkeys exposed during pregnancy and after birth through nursing (ATSDR 1998). EMEGs are very conservative and protective values. Generally, if soil concentrations do not exceed the EMEG, ATSDR assumes that exposure is not likely to result in adverse health effects. However, if soil concentrations exceed the EMEG, this does not mean that adverse human health effects will always occur. Instead, soil concentrations greater than 50 ppt total dioxin TEQ indicate further site-specific evaluation is necessary (De Rosa et al. 1997a).

In 1997 and 1998, the MDEQ collected soil samples from 68 urban and rural locations in Michigan (MDEQ, Waste Management Division. 1999. Michigan Soil Background Dioxin Data). These samples were taken to gain an understanding of statewide DLC concentrations that have resulted from industrial activities, waste incineration, and chemical use. Analysis of these samples indicates that DLC soil background concentrations vary from less than 1.0 ppt TEQ to 35 ppt TEQ with an average of 6.0 ppt TEQ. Similar nationwide efforts by the U.S. EPA found an average DLC soil concentration of 10 ppt TEQ (MDEQ 1999).

Twenty-two properties were originally sampled for the PEI. Soil analytical results for only 15 properties showed levels of DLCs greater than the MDEQ residential cleanup criterion of 90 ppt. This suggests that predicting whether an individual property is impacted is not as simple as just determining whether the property lies within the 100-year flood plain or if the Tittabawassee River has flooded it. On impacted properties, levels of DLCs tended to be higher nearest the river but this pattern was not apparent for all properties indicating that human movement of soil is a significant way soil could become contaminated with DLCs.

Because the numbers of PEI participants and properties are small, determining whether DLC levels in soil correlate with levels found in participant's blood is not possible.

Indoor Dust

Detectable DLCs were found in all dust samples collected from the homes of PEI participants. These samples were analyzed to qualitatively determine whether DLCs were present in homes located on properties where soil had been impacted by DLCs. No state or federal criteria or guidelines exist for the acceptable level of DLCs in indoor dust. The human health effects of exposure to DLCs in indoor dust are not known.

Blood

All people in the United States are believed to have some level of DLCs in their body fat and blood (ATSDR 1998). DLCs are found throughout the environment and most people are exposed to low levels in air, soil, or food. In areas that have not been impacted by an accident or other release, background DLC levels in soil are around 6 to 10 ppt (MDEQ 1999). For people living in these areas, most of their intake of DLCs comes from eating foods of animal origin, such as meat, poultry, fish, or dairy products (ATSDR 1998). DLCs are in these foods because they are in the animals' environment and because DLCs tend to accumulate in the fatty tissues of animals and fish.

People who live in or near areas such as the Tittabawassee River flood plain, where the level of DLCs in environmental media (e.g., air, soil or sediment) and biota (e.g., animals and fish) are higher than background, may be exposed to above-background levels of DLCs (ATSDR 1998). DLCs have been detected in the flood plain at concentrations up to 7,300 ppt in soil and 2,100 ppt in river sediments (MDEQ 2003). The contribution of DLC intake from exposure to soil and sediment in the flood plain to a person's total intake of these chemicals will likely be higher than background.

The Michigan Fish Advisory cautions against eating carp, catfish, and white bass taken from the Tittabawassee River because these fish have been found to contain unacceptable levels of DLCs. Women of childbearing age and children also are cautioned not to eat smallmouth bass. Limited consumption is recommended for all other fish species such as walleye (MDCH 2003). On September 14, 2004, the MDCH issued a Wild Game Advisory for the flood plain, recommending that people not eat the liver of white-tailed deer or turkey meat and skin, and limit their consumption of deer and squirrel muscle meat (MDCH 2004c). This advisory was based on elevated levels of DLCs that had been found in the edible tissues of these wild game

species. People who eat fish or wild game taken from this area may be exposed to higher than background levels of DLCs.

When people eat foods or are exposed to air, soil or sediment that contain DLCs, these chemicals can accumulate in their bodies. People who are exposed to higher levels in the environment and in food will tend to accumulate more DLCs in their bodies. Most of the DLCs are stored in adipose tissue (fat), blood serum, and the liver, and can remain in the human body for many years. The time it takes to remove one-half the amount of 2,3,7,8-TCDD in a person's body is 7 to 12 years (ATSDR 1998). Other congeners may take more or less time to be eliminated from the human body. The amount of DLCs in a person's body is often referred to as the "body burden" and will be different for each person depending on how much they are exposed to, how much they absorb into their body, and how fast they eliminate these compounds. Age, gender, and health status can all affect how fast DLCs will accumulate and be eliminated from a person's body (ATSDR 1998).

Blood serum samples generally are used to measure a person's body burden of DLCs, although these compounds have been found in all tissues and in breast milk. These tests are not routinely available to the public.

All serum TEQ levels measured in blood samples provided by the PEI participants fell within the range of preliminary estimated background TEQ levels shown in Table 1. However, the mean TEQ levels for age groups 45-59 years and 60 years and older were higher than the mean background estimates for people the same age. Because of the small number of people participating in the PEI, generalizing from these limited results to the larger population living in or near the flood plain is not possible.

Conclusions

The interview questionnaire and the soil, dust, and blood sampling methods were adequate to meet the purpose of the PEI. Redundancy in questions concerning occupational history on the interview questionnaire should be eliminated.

Soil samples collected from 15 properties located at least partially within the flood plain of the Tittabawassee River showed total dioxin TEQ levels greater than the MDEQ residential criterion of 90 ppt for DLCs. These findings further confirm earlier results indicating that elevated DLC levels within the 100-year flood plain downstream of Midland are widespread.

Indoor dust samples collected from homes located on properties where outdoor soil contains levels of DLCs greater than 90 ppt confirm the presence of DLCs in the indoor environment of these homes.

The mean total dioxin TEQ level in 10 adult PEI participants aged 45 to 59 years was higher than the mean estimated background level for this age group. The mean 2,3,7,8-TCDD level in this PEI group was also higher than the estimated mean value in the background data.

Total dioxin TEQ blood levels in four participants aged 45 to 59 years were greater than the 90th percentile of the estimated background levels for this age group. Two of these were also greater than the 95th percentile. Total dioxin TEQ blood levels in these four participants are elevated.

The mean total dioxin TEQ level in nine adult PEI participants 60 years of age and older was slightly higher than the mean estimated background level for this age group, but fell within the 95% confidence intervals for the estimated background mean. The mean 2,3,7,8-TCDD TEQ in this PEI group was also higher than the estimated mean value in the background data, but again fell within the 95% confidence intervals for the estimated background mean. Therefore, whether these data reflect a real difference between the PEI participants and the estimated background levels cannot be known for certain.

The total dioxin TEQ blood level in one participant in the 60 plus age group was greater than the 90th percentile of the estimated background comparison level and is elevated.

Although, mean serum TEQ and 2,3,7,8-TCDD levels in the PEI groups were higher than the estimated background levels, all TEQ and 2,3,7,8-TCDD levels observed in the PEI participants fell between the lowest and highest values observed in the estimated background data.

Recommendations

- The PEI interview questionnaire should be revised to eliminate redundancy in the occupational history questions before the questionnaire is widely used.
- A comprehensive exposure investigation should be conducted to evaluate the potential for unacceptable human exposures to DLC contamination in flood plain environmental media and biota including:
    - Identification of properties where DLC concentrations exceed applicable State of Michigan clean up criteria and/or the ATSDR screening level.
    - Evaluation of the bioavailability of DLCs in flood plain soils and sediments.
    - Identification of DLC levels in fish, wild game, and domestic animals or animal products in the flood plain and eaten by people.
    - Identification of people who may be more highly exposed to flood plain DLCs such as fishers, hunters, or people who are highly exposed to soil contamination.
- Actions should be taken to limit exposures to elevated DLC levels in environmental media and biota.

Public Health Action Plan

- MDCH and ATSDR will revise the interview questionnaire before it is used again.
- MDCH and ATSDR will remain available to participate in the development or review of work plans to conduct a comprehensive exposure investigation for the Tittabawassee River and flood plain.
- MDCH and ATSDR will consider the feasibility in conducting health outcome studies to determine if rates of disease for people living in or near the flood plain differ from persons who live in a comparison location, if a comprehensive exposure investigation

identifies environmental dioxin exposure in or near the floodplain is above background levels.

- MDCH and ATSDR will continue to provide health education to residents and health care professionals so that they can make informed decisions to limit their exposure to DLCs.
- MDCH will maintain and update fish and wild game advisory information for the Tittabawassee River and flood plain.

Contact Information

If any citizen has additional information or health concerns regarding this Tittabawassee River flood plain Pilot Exposure Investigation consultation, please contact the Michigan Department of Community Health, Division of Environmental and Occupational Epidemiology at 1-800-648-6942.

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Tittabawassee River Floodplain

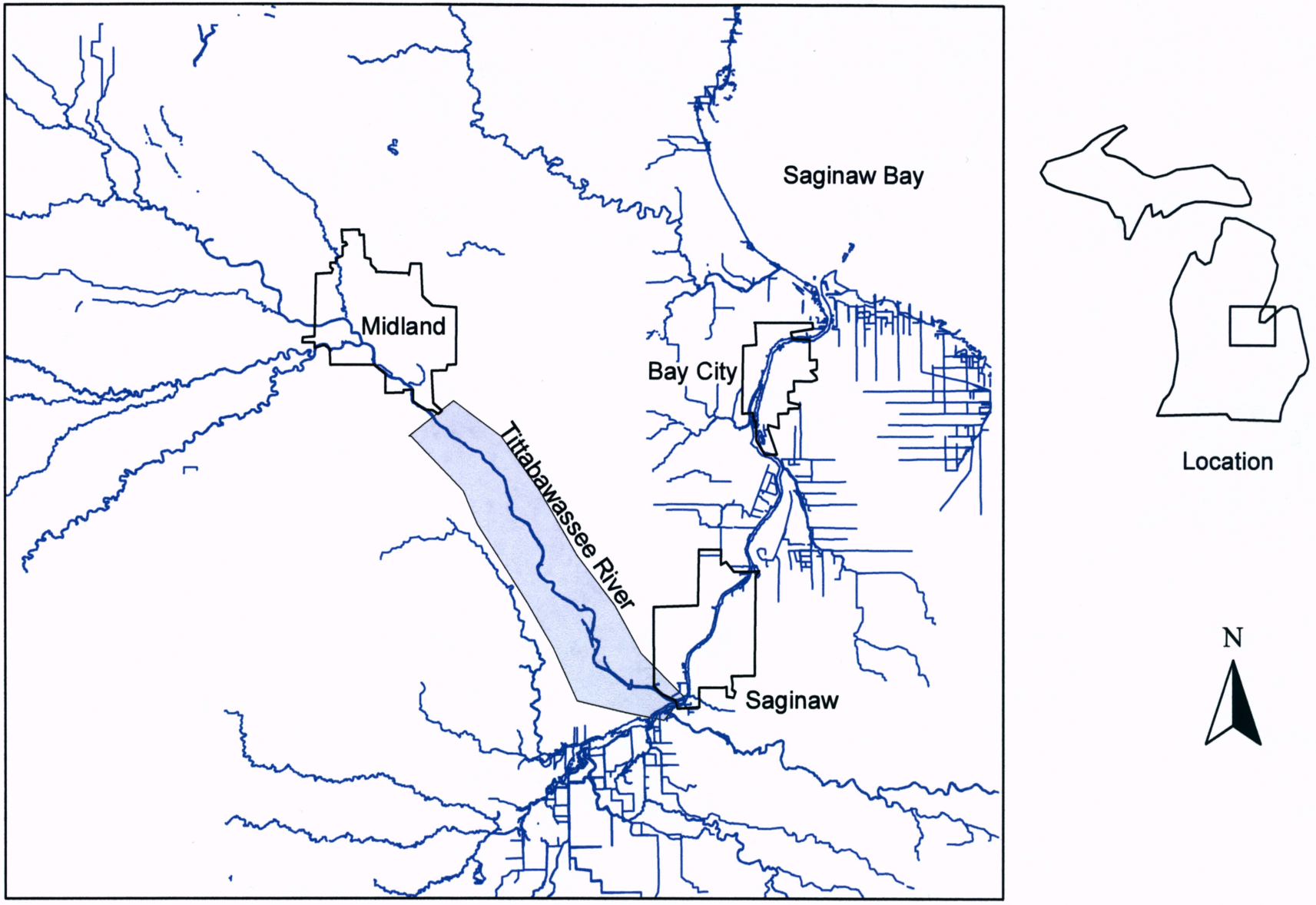


Figure 1.

Figure 2.
Comparison of Estimated Background and PEI dioxin TEQ (ages 45-59)

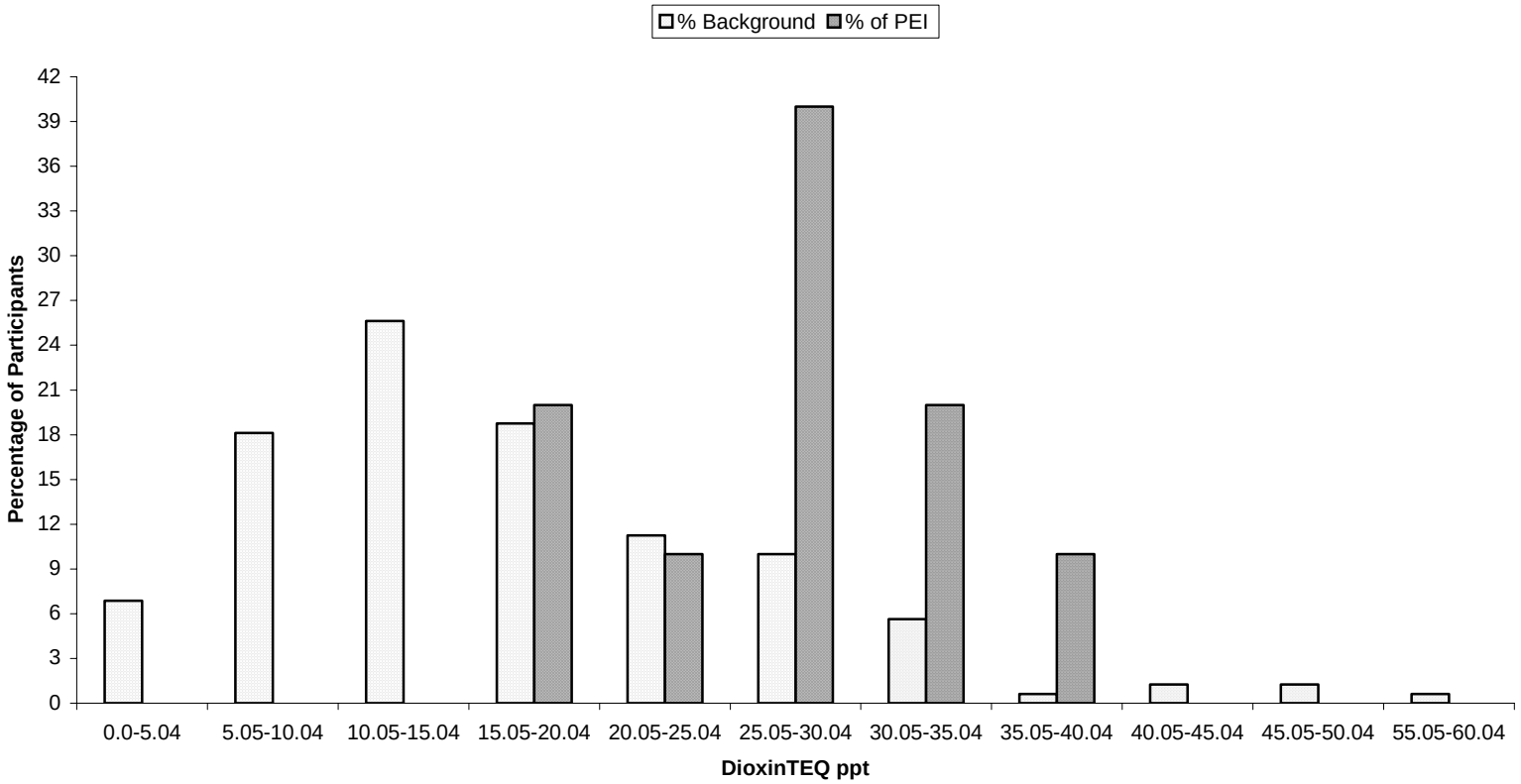
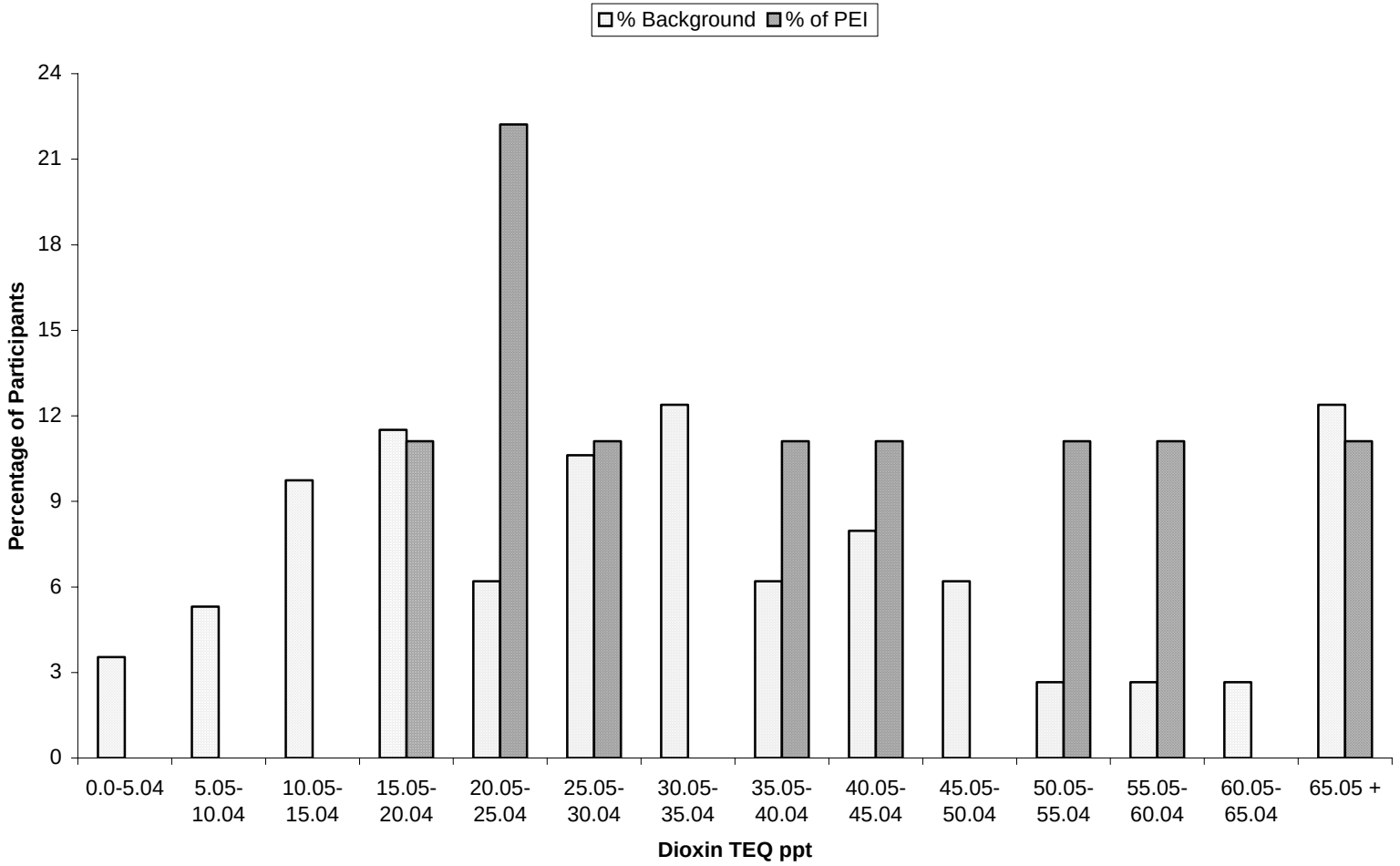


Figure 3
Comparison of Estimated Background and PEI dioxin TEQ (ages 60 years and older)



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Certification

This Tittabawassee River Floodplain Health Consultation was prepared by the Michigan Department of Community Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

Technical Project Officer, CAT, SSAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

for Chief, Cooperative Agreement Team, SSAB, DHAC, ATSDR